2

The first lesson in the classroom – getting students engaged in active learning process

Annette Eva Langkilde

Department of Medicinal Chemistry, FARMA, University of Copenhagen

Introduction

The aim of this project was to search for alternative ways of encouraging the students to take an active part in the classroom, and to break from the traditional walk-through of exercises on the blackboard.

The focus in this report is on the initiatives made for the first session, as I believe the impressions from the first encounter have a crucial impact on the rest of the course programme. If the students walk away from the first session with a good "feeling" of being capable, and at the same time getting something out of showing up and participating, the positive attitude will affect the following lessons.

Description of the course

Organic Chemistry I (M31) is a mandatory course in the first semester for all students at the Faculty of Pharmaceutical Sciences. The official course description (in Danish) is included in Appendix A. The course consists of lectures with 200-250 students, classroom exercises with 30 students per class (i.e., eight more or less parallel classes). In addition, a study-café is held five times during the semester, with older students being available for help in three connected courses. A second part of the course in the following semester also included practical laboratory exercises.

The content of this project is focused on the classroom exercises, which I have taught, with particular focus on the first lesson. The classroom teaching is organized as twelve double lessons (2×45 min) of which one involves specific exercises at computers. In the following, I will use the term first lesson to refer to the first double lesson (i.e., 2×45 min). Suggested exercises are chosen by the teacher responsible for the course, and the classroom teachers meet prior to the start of the course to discuss possible approaches to the classroom teaching and their previous experiences.

Generally, Organic Chemistry is a course the students evaluate positively and the students are generally motivated, despite the fact that it may well be considered a tool-box course.

Initial plans and aims for the first lesson

- Questionnaire and a general discussion on mutual expectations. Questionnaire first to give the individual student a moment to think about his/her own expectations before a general discussion.
- Introduce myself: name, affiliation, teaching experience, motivation, taking part in a pedagogical course.
- Learn student names (or at least start to).
- Student activity. Play the game cards. See a more detailed description below.
- Evaluate the game. Ask students what they successfully explained to each other and what is still problematic. Did they like the cards?
- Close unresolved questions in a general discussion by the end of the lesson.

Overall aim: Set the scene for high level of student activity and a good atmosphere for the learning process.

The game cards

Inspired by a group of students attending the course last year, we (the team of classroom teachers for the course) made a card game for the final session before the summer break (i.e., the second part of the organic chemistry course). Several of the students mentioned it would have been great to do this earlier. Thus, this was the inspiration for this part of the project.

The aim is to work through the planned exercises as game cards in small groups of four or five students. The group is given a set of cards, and without using their books (or at least only after a thorough discussion) the students take turn in picking a card with a question. The student should not

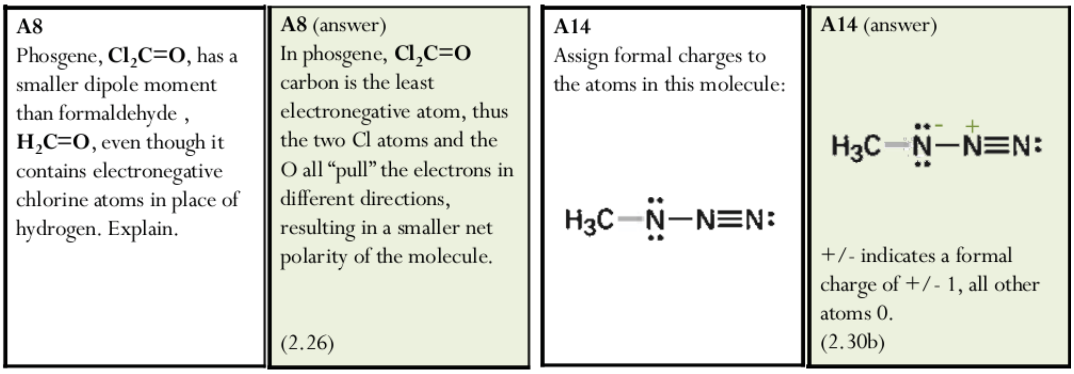


Fig. 2.1. Examples of two game cards from the first lesson. See more in Appendix B.

only answer but also explain how or why he or she arrived at this answer. If needed, the group may help and finally the answer can be checked on the back of the cards. To keep a positive atmosphere, the level of competition is left up to the individual group, and no winners or losers are announced.

As the suggested exercises for the classroom teaching were posted on the course homepage prior to the lesson, I decided to base the questions on the game cards (see above and Appendix C) on these exercises. I chose this to avoid well prepared students feeling their preparation was superfluous, but instead to reinforce the well prepared students' self-efficacy as they experienced improved understanding and ability to explain to their peers thanks to their preparation. Turning it into a game should give all group members a chance to be the one to explain (as they take turns in picking random cards) and a bit of fun may even stimulate the intrinsic value for the student.

My role during this game (as well as later sessions with group work) is not to give the answers when asked, but try to assist the students in finding the answer themselves.

Implementation

The first lesson was attended by 28 students (of 30 listed). Overall, the plan was followed, though I chose to start the name-learning as the groups were "playing", as this gave me a chance to interact a bit more closely and add a few names to the faces at the same time.

The students were very willing to answer the questionnaire. They had several and very widespread suggestions as to what they would like during the classroom teaching, including the “classic” teacher-go-through-all-exercises-at-the-blackboard-while-we-(passively)-take-notes scenario, which was the only thing I ruled out on the spot.

Regarding the card game, the students engaged in great discussions, while I circulated among the groups, on request to assist or on my own initiative to “listen in” and learn names.

All in all, there was a very positive atmosphere and I left feeling motivated for the lessons to come.

Evaluation

The course was taught during the autumn of 2010, and as the Bachelor’s degree part of the studies at the Faculty of Pharmaceutical Sciences is still running over semesters, the students had not yet sat the exam for this course (scheduled for January 2011). Thus the evaluation is based on student feedback (primarily from the first and last lessons) as well as my own reflections (from both the first session and the overall course programme).

The first encounter

Student responses on expectations and my comments

I prepaired and distributed a small questionnaire[1] to give me written responses as well as to give the students a moment to think about their own expectations before a general discussion and also an opportunity to comment anonymously. The second half of the questionnaire focused on a statement from the course homepage on our (the teachers’) general expectations.

A large part of the students would prefer the teacher to go through all exercises, which was also mentioned in the following general discussion. Slightly contradictory to this, the majority also thought students should go through the exercises.

The group was completely split on the question of working with the exercises and syllabus during the lessons. Thus this is a point where it will be

[1] The questionnaire handed out to the students was in Danish.

	Strongly disagree	Disagree	Agree	Strongly agree
The teacher is prepared for the class	0	1	5	21
The teacher go through all exercises	0	10	14	3
The teacher go through selected exercises	1	4	11	12
Students have solved (or attempted to solve) all exercises prior to the lesson	0	0	11	16
Students work with the exercises/syllabus during the lessons	3	10	12	2
Students go through exercises	2	4	16	4
I'll be (expect to be) prepared for the lessons	0	1	11	15
I expect to participate in all lessons	0	0	12	15
I'll choose lessons depending on theme or other...	7	15	3	0

Fig. 2.2. Answers from the first part of the questionnaire.

challenging to please everybody. However, it is in this scenario that much is learned and it is part of the "official" aim of these lessons that in some form will be a large part of the sessions. In the general discussion, I received several good comments on how this could be done, many of which were implemented or tested during the course programme, e.g. prioritize the suggested exercises at the beginning of the session or after the group work session, then discuss in this order, to address the most difficult first.

The second part of the questionnaire included a statement from the course homepage (Appendix B), concerning some general expectations from the course organizers/teachers on how the classroom lessons will run. I had previously assumed that all the students had read this, but for this class, I printed the statement on the second page of the questionnaire (i.e. not visible when answering the first part) and asked:

1. Have you read this statement from the course homepage?
2. Has it changed your expectations?

There was room for additional comments.

Much to my surprise, only half of the students had actually read the statement. One commented that she knew about it (presumably from other students) and thus it did not change her expectations.

The fact that most students (20) say that this statement had not changed their expectations suggests that the students have had very similar expectations, which is not really reflected in the fact that the majority expect me as teacher to go through all the exercises as seen from the first half of this questionnaire. Alternatively, they still hold on to whatever expectations they have regardless of this statement. In any case, it prompted a fruitful discussion during our first session.

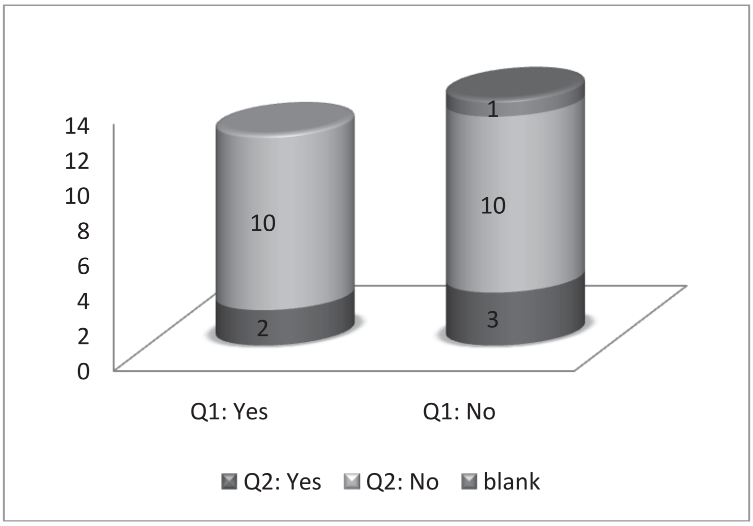


Fig. 2.3. The answers to the questions regarding the statement written on the course homepage.

Playing the game

The response to the game was very enthusiastic and the students took on the challenge with no complains. The game format, with a loose rule of no books (or as limited reference to books as possible) prompted more peer discussion and less flipping around in the books. I was circling the groups, sometimes on request, but just as often on my initiative, as the students resolved most issues in the groups.

The immediate evaluation was very positive, in terms of successful experiences with having explained things to peers and having understood something from the group. Most of the groups struggled to come up with an unresolved question. Perhaps this reflected the exercises being at the easy end of the scale, with some exercises summarizing a few things from their high-school syllabus.

In the end, by focusing on what was explained well by peers, hopefully the students self-efficacy in smaller groups had increased, thereby the students should be more likely to participate in full class discussions. Also by not forgetting to close the lessons with a general discussion on the final unresolved issues the aim is that the students walk away from the class, feeling like they "got something out of it", i.e., increased (or at least attained) the value of these lessons for the individual student.

Reflections based on the entire course program

Previously, when I have taught this course (12 double lessons) I have experienced very low attendance rates – at worst two students. Although this class coincided with project work in another course, it was still not very motivating). The group of teachers involved in the course, have introduced group work as a major part of the classroom lessons, but I felt reluctance towards this from a majority of the students, and several kept asking for the traditional walk-though of exercises.

With this class from autumn 2010, my experiences have generally been much more positive. The attendance rate has also been high (mostly 20+ students), the lowest being the lessons from 8-10AM with no other lessons scheduled with twelve students attending. Of course, other factors may have a significant influence on this; i.e. I think the coordination with other courses has improved. Project work with hard deadlines in other courses was at least part of the reason for the very low attendance rate experienced previously.

Throughout the course the students have been free to form groups as they pleased, and in connection with a supervision session I noted how these group formations were more dynamic than I expected and had previously noticed. The students are not sitting with the same group every time. According to Biggs and Tang ((2007)), referring to Yamane, there would be a higher likelihood of gossip and off-task discussion in this kind of free-formed groups. I have not (yet) compared them with the discussion level in groups that I have chosen, but I have been impressed thoughout the course with the level of discussion among the students and the enthusiasm they have shown towards the work. It has not been easy to enforce breaks between the two connected 45 min lessons, as students continued to ask questions, in groups and individually.

Throughout the course the students have given feedback in a very positive tone, on what they liked/disliked, resulting in many smaller variations throughout the programme. Generally, at least half of the time has been dedicated to group work and discussions, while there have been variations in how much time was spent before or after on general introduction and discussion or students going through exercises at the blackboard.

When it comes to the students at the blackboard, it was dominated for quite some time by just a few students volunteering. Inspired by the pedagogical supervision during one of the lessons, we tried assigning different exercises to groups which raised the amount of students actively participating at the blackboard. This can still be improved, however.

As a last aspect, I also realize that I am still struggling slightly with the concept of coverage. It is described by Biggs and Tang (2007, p. 40) in terms of students being overloaded, but I sometimes feel some guilt (for want of a better word) when I have not discussed all the problems. I am convinced that the deeper approach and detailed discussion of a single or fewer problems is more valuable than a list of answers with a quick or no explanation, but I believe the residual struggle is a result of the way I was most often taught (we or the teacher did go through all listed exercises at the blackboard). Thus the ongoing task is to keep encouraging a deep approach to learning. This can be done, for example, by showing students what they can gain from understanding the basic principles of a chemical reaction instead of learning how to solve specific types of exercises, showing that with the basic principles one can “recognize” this in most reactions and then be able to predict the product in reaction types that are new to the student.

Conclusions

I found that the open discussion of the students’ expectations was very useful and we had smaller similar sessions throughout the course. Assuming we all know at least has not worked for me before. It may take up time from the exercises, but this is time well spent! The students gain more ownership as they have a large influence on the format. When asked for feedback at the end of the course, where I assumed they would remember the game from the first lesson, several marked the discussion of expectations as a key element from the first lesson.

I have used group work or learning cells throughout the course, mainly to have the students take an active part in the learning process, in discussions with their peers. Formulating what they do not understand and explaining subjects to others are both challenging and useful exercises.

As the hours allocated to this course have been decreased, there are no longer hand-in exercises in this course, thus an advantage of the group work during class is that it also gives me as the teacher an opportunity to better follow the individual student and know their capabilities better. The interaction with a small group allows me to follow the individual’s expressions and notes, and some students may feel more free to ask questions or ask for alternative explanations when with a small group. Thus, overall, I get a more nuanced picture of the capabilities in the class than I would have from the “classic” blackboard teaching.

The card game was a successful ice-breaker in the first session and illustrated some important points of group work. Games like this are not to be used all the time, but may help engage the students. I had originally planned to use it more times, and even had the cards prepared once, where the students chose to work differently with the problems. For that given lesson, I had misjudged the capabilities and needs of the students and thus adjusted accordingly. However, I have searched for more inspiration from other games, e.g. Chemistry Taboo (Capps (2008) and references herein) and Where’s Ester (Angelin & Ramström; 2010) and believed that a few varied sessions like this could be helpful in many ways as this card game was for this group of students.

There are many more aspects to the classroom teaching that I have not touched upon here, but doing this project work and searching through literature for it I found much more inspiration, e.g. on how to employ “minute papers” and “fish bowls” (as described and further referenced in Paulson, 1999). Some of all this inspiration will be implemented in the coming semester where I look forward to continue teaching the same group of student more organic chemistry.

A Course description in Danish

From August 2010.

Praktiske oplysninger

Status: Obligatorisk på bacheloruddannelsen i farmaci
Tidspunkt: 1. semester - efterår
Undervisningsform: Forelæsninger og klasselektioner. Undervisningen støttes af hjemmeopgaver.
Kursusomfang: 6,5 ECTS-points
Timetal: 24 forelæsninger á 45 min. og 24 klasselektioner á 45 min. (afholdes som 12 dobbeltlektioner)
Frekvens: 1 gang årligt
Prøve:

- Prøveform: Skriftlig prøve af 2 timers varighed
- Bedømmelse: Bestået/ikke bestået
- Bedømmere: Faglærer(e) uden medvirken af censor
- Tilladte hjælpemidler: Brug af molekylmodelbyggesæt ellers ingen
- Særlige forhold: Prøven, der er en del af 1.årsprøven, afholdes i januar.

Reprøve afholdes lige før eller lige efter påske, jvfr. regler om 1.årsprøven.
Undervisningsmateriale: J. McMurry: Organic Chemistry with Biological Application. 2nd ed. 2011, Brooks/Cole
Sprog: Dansk

Formål

Kurset har til formål at indføre den studerende i de grundlæggende begreber inden for organisk kemi, herunder:

- Simple organiske forbindelsers molekylstruktur
- Basal stereokemi
- Enkelte kemiske reaktioner og deres reaktionsmekanismer, så som addition, elimination, nukleofil substitution og nukleofil addition til carbonylgrupper
- Tolkning af IR- og 1. ordens 1H-NMR-spektre.

Indhold

Kurset består af 24 forelæsninger og 24 klassetimer (som dobbelttimer).

I forlæsningerne gennemgås stoftyperne: alkaner, cykloalkaner, alkener, alkyner, aromatiske carbonhydrider, alkylhalider, alkoholer, phenoler, thioler, ethere, sulfider og oxoforbindelser. For hver stoftype berøres: molekylstruktur (herunder stereokemi og resonansformer), fremstilling, fysiske egenskaber og kemiske reaktioner. I forbindelse med de kemiske reaktioner gennemgås mekanismerne for: addition, elimination og substitution. Endvidere vil forelæsningerne omfatte introduktion til UV-, IR- og 1H-NMR-spektroskopi. I klasselektionerne arbejdes med opgaver til understøttelse af det teoretiske pensum. Endvidere vil de studerende blive trænet i at tolke IR- og 1. ordens 1H-NMR-spektre. I forbindelse med klassetimerne tilbydes 2 hjemmeopgavesæt, hvoraf det sidste opgavesæt er et eksempel på et eksamenssæt.

Formeltegningsprogrammet ChemBioDraw vil blive introduceret i en dobbeltlektion.

Målbeskrivelse

Efter kurset skal den studerende

- Kunne redegøre for de i pensum omtalte stoftypers opbygning og deres systematiske navngivning
- Kunne opskrive konstitutions- og konfigurationsformler for simple organiske forbindelser ud fra deres systematiske navne
- Kunne redegøre for de i pensum omtalte reaktioner og deres reaktionsmekanismer
- Kunne redegøre for oprindelsen og udseendet af signaler i UV-, IR- og 1. ordens 1H-NMR-spektre.

De nævnte kundskaber skal kunne anvendes med henblik på

- At navngive simple organiske stoffer efter IUPAC-reglerne
- At beskrive et stofs struktur, herunder molekylgeometri, relativ og absolut konfiguration samt isomeri-muligheder
- At skønne over et stofs fysiske egenskaber, herunder opløselighed, smeltepunkt og kogepunkt, på basis af molekylstruktur
- At foreslå reagenser til gennemførelse af kemiske reaktioner
- At forudsige forløbet af simple reaktioner
- At kunne udlede strukturen af simple organiske forbindelser ud fra stoffets IR- samt 1H-NMR-spektre.

Studenterbelastning

	Antal timer
Forelæsning	24
Forberedelse	48
Klassetimer	24
Forberedelse	48
Eksamen og eksamensforberedelse	35
Totalt antal timer	179

Kursusansvarlig

Bente Frølund, Institut for Medicinalkemi

B Quote from the M31 course homepage (in Danish as originally stated)

> *Klassetimer*
> Klassetimerne er et forum, hvor du som studerende selv skal arbejde med stoffet.
>
> Til hver klassetime vil der være foreslået et vist antal opgaver, som relaterer sig til det gennemgåede pensum i forelæsningerne.
>
> *Opgaverne skal forsøges løst inden klassetimerne*
> For at opnå optimalt udbytte af klassetimerne er undervisningen baseret på at opgaverne er forsøgt løst inden klassetimen, evt. sammen i mindre læsegrupper. Klassetimerne skal bruges til at få afklaret specielt vanskelige opgaver.
>
> *Løsninger på opgaver kan findes i Study Guide*
> Det kan ikke forventes at alle opgaverne bliver løst i løbet af klassetimerne. Løsninger til opgaver fra lærebogen: 'Organic Chemistry with Biological Applications' kan findes i den tilhørende Study Guide. Study Guiden kan evt. lånes på bibliotektet eller købes, evt. sammen i læsegrupperne.

Translation of the statement from the course homepage:

Classroom lessons
The classroom lessons represent a forum where students themselves work with the syllabus.

For each class lesson a number of problems or assignments that relate to the syllabus of the lessons will be proposed.

The problems should be attempted solved before the lessons
To obtain optimal yield of class lessons, teaching is based on the assignments having been tackled before class lessons, possibly in small reading groups. Class lessons are aimed at clarifying particularly difficult problems.

Solutions to the assignments can be found in the Study Guide
It cannot be expected that all assignments are solved during class hours. Solutions to assignments from the textbook 'Organic Chemistry med Biological Applications' can be found in the corresponding Study Guide. The Study Guide may be borrowed from libraries or purchased, e.g. together in reading groups.

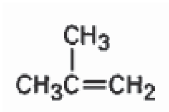
C Examples of game cards used in the classroom

The cards were printed two-sided (Question/Answer):

A1
State the expected hybridization for each C atom in this compound:

$CH_3CH_2CH_3$

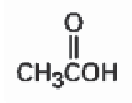
A2
State the expected hybridization for each C atom in this compound:



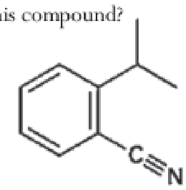
A3
State the expected hybridization for each C atom in this compound:

$H_2C{=}CH{-}C{\equiv}CH$

A4
State the expected hybridization for each C atom in this compound:

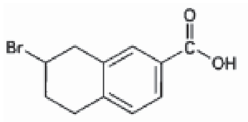


A5
How many hydrogens are bound to the C atoms in this compound?



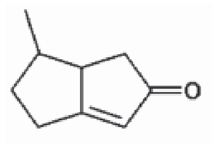
… and state the molecular formula of the compound.

A6
How many hydrogens are bound to the C atoms in this compound?



… and state the molecular formula of the compound.

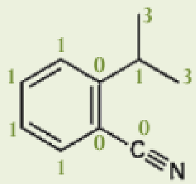
A7
How many hydrogens are bound to the C atoms in this compound?



… and state the molecular formula of the compound.

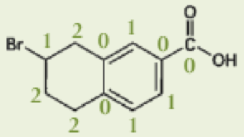
A8
Phosgene, **$Cl_2C{=}O$**, has a smaller dipole moment than formaldehyde , **$H_2C{=}O$**, even though it contains electronegative chlorine atoms in place of hydrogen. Explain.

A5 (answer)
No. of hydrogens bound:



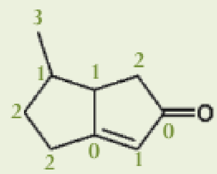
Molecular formula:
$C_{10}H_{11}N$
(1.42a)

A6 (answer)
No. of hydrogens bound:



Molecular formula:
$C_{11}H_{11}O_2Br$
(1.42a)

A7 (answer)
No. of hydrogens bound:

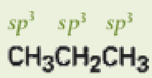


Molecular formula:
$C_9H_{12}O$
(1.42a)

A8 (answer)
In phosgene, **$Cl_2C{=}O$** carbon is the least electronegative atom, thus the two Cl atoms and the O all "pull" the electrons in different directions, resulting in a smaller net polarity of the molecule.

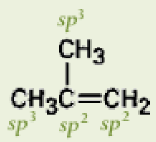
(2.26)

A1 (answer)
Expected hybridization of C atoms:



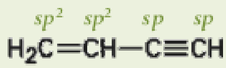
(1.33 a)

A2 (answer)
Expected hybridization of C atoms:



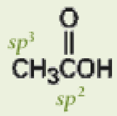
(1.33 b)

A3 (answer)
Expected hybridization of C atoms:

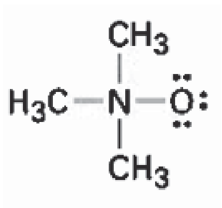
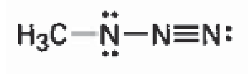
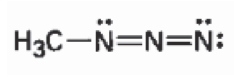
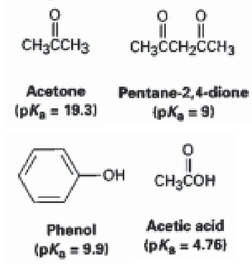


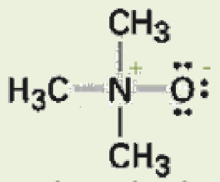
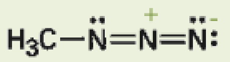
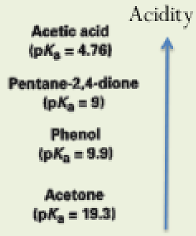
(1.33 c)

A4 (answer)
Expected hybridization of C atoms:



(1.33 d)

A9	A10	A11	A12
Which bond is more polar? Indicate the direction of bond polarity for each compound. **H_3C–Cl** or **Cl–Cl** Use the electronegativity table.	Which bond is more polar? Indicate the direction of bond polarity for each compound. **H_3C–H** or **H–Cl** Use the electronegativity table.	Which bond is more polar? Indicate the direction of bond polarity for each compound. **HO–CH_3** or **$(CH_3)_3$Si–CH_3** Use the electronegativity table.	Which bond is more polar? Indicate the direction of bond polarity for each compound. **H_3C–Li** or **Li–OH** Use the electronegativity table.
A13 Assign formal charges to the atoms in this molecule: 	**A14** Assign formal charges to the atoms in this molecule: 	**A15** Assign formal charges to the atoms in this molecule: 	**A16** Rank in order of increasing acidity: 

A13 (answer)	**A14** (answer)	**A15** (answer)	**A16** (answer)
 +/- indicates a formal charge of +/- 1, all other atoms 0. (2.30a)	 +/- indicates a formal charge of +/- 1, all other atoms 0. (2.30b)	 +/- indicates a formal charge of +/- 1, all other atoms 0. (2.30c)	 A lower pKa value indicates a stronger acid (2.38)
A9 (answer) δ^+ δ^- **H_3C–Cl** most polar +→ **Cl–Cl** Non-polar (2.28a)	**A10** (answer) **H_3C–H** Non polar (EN difference <0.4) δ^+ δ^- **H–Cl** most polar +→ (2.28b)	**A11** (answer) δ^- δ^+ **HO–CH_3** most polar ←+ δ^+ δ^- **$(CH_3)_3$Si–CH_3** +→ Larger difference in EN, more polar (2.28c)	**A12** (answer) δ^- δ^+ **H_3C–Li** ←+ δ^+ δ^- **Li–OH** most polar +→ Larger difference in EN, more polar (2.28d)

All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2010-3-1/

The bibliography can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/kapitler/2010_vol3_bibliography.pdf/